With H. Bovey's Compts

ADDRESS OF

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PRESIDENT

OF

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The Canadian Society of Civil Engineers.

PRESIDENT'S ADDRESS.

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Before commencing the few words which I propose to address to you to-day, I feel constrained to make, on behalf of the Society, a brief reference to the irreparable loss which is now being felt throughout the length and breadth of our Empire.—A great nation is in mourning.

Among all the forces which make for unity, among our federated Societies, our Associations, our States and Dominions, no name of union linking men together, not even a word like that of liberty, for which men have been willing to die, has half the force of a great personality.

Such a personality has just passed off the stage of human life. Our Queen is dead. But let no man think that the link has gone. We are not so made. Because we have rejoiced together over our Queen's Jubilee, and no less because we have mourned together over her bier, shall we be more closely joined as a nation in spirit and in sympathy—all ranks and classes helping one another, and all resolutely standing round the throne of our King to uphold in the new reign the same principles of honour and of righteousness on which the true greatness of the old was built.

"I hold the years in my heart,
And all that was is yet."

As engineers we have a special part to play in this ideal. We can, as it were, supply the physical means—the body—by which this spirit can work its will. Can anyone suppose that without the engineering triumps of the telegraph, the railway, the steamship, we could have seen the natural federation of the Empire under the influence of a common emotion which has taken place before our eyes while we were discussing plans for bringing it about, and which, if it goes on to completion, can scarcely but be regarded by future times as the crowning glory of the reign of Victoria.

THE PLACE OF SCIENCE IN EDUCATION.

Those who have been called upon to speak on such an occasion as this will easily imagine that I have had some difficulty in deciding upon the subject to which I would call your attention. Our entrance upon society life in a building of our own, very naturally suggested to me that this would be a suitable moment in which to review our progress as a Society from small beginnings in 1887, to what, we may surely hope, is a position of public usefulness and great promise of permanence. When, however, I considered our entrance at the same time into a new century, and what a vantage ground that imaginary line gave us in making a survey of the progress of engineering in general, I could not but feel that the little history of our Society's effort to embrace this Dominion with our still undeveloped arms, would be quite out of proportion to the height of our post of observation.

Even the progress of engineering in general, amazing as it has been, is only one of progressions so vast that I confess that at this stage I thought it time to consider my powers and their limitations, and that it was not impossible that I might perhaps run up against the limits of your patience. On the other hand, I was unwilling to forget either the words or the spirit of the old philosopher who said, "I hold every man a debtor to his profession; from which as men of course do seek to receive gratification and profit, so ought they of duty to endeavour themselves, by way of amends, to be a help and ornament thereto." Possibly, also, I was influenced by the fact of my own special connection with the training department of our profession. In any case, I finally decided on a subject, to which my attention had been naturally drawn, and on which it is very desirable to come to a distinct understanding; as upon that understanding all sound conclusions as to the value of university training for the engineer must be based. I will ask your kind attention, then, to the consideration of "The Place of Science in Education."

I have spoken of engineering as a profession. Unless we can also speak of it as a Science, we may naturally ask, how it is true that our conclusions must be based on the right understanding of the place of science in education?

Engineering is a term which has been chosen for its general usefulness, and has been applied to so many things that it is difficult to seize its essential characteristic. It so happens that certain investigations into the chemical and physical properties of matter, into the dynamics of steam, electricity, etc., have been made by the engineer rather than by the physicist and the chemist, because these investigations have been required by the practical work of the engineer, and because they have sometimes to be carried out

on a scale inconsistent with the more delicate experiments which are the chief occupation of a physical laboratory. So it has come to pass, as a matter of convenience mainly, that engineering, besides being a profession, has been made directly responsible for certain scientific work, and may in this light be looked upon as in itself a Science. Further, perhaps as its proper training seems to involve a considerable acquaintance with mathematics, as well as with one or more of the natural Sciences, of which I have spoken, the study of engineering in general may be considered as synonymous with the study of a particular combination of sciences, joined together with a view to a direct practical result. A special application of this statement will be spoken of later, but in the meantime it will be sufficient for our purpose to recognize that engineering, so far as it affects education, is to be grouped with the Sciences, and that what may be said of them may be said of engineering. It has certainly been the needs of my own profession which have caused me to give so much attention to the effect of a scientific training upon the minds of young men, and to the best methods of securing its advantages.

So much has already been said and written on this subject, that it seems at first as if all must have been said that could be said. Until, however, we have exhausted the records of experience, and until we have been able to map out the human mind—scientifically, of course—there will be much to learn on this as on every other educational subject, and if I am able to contribute nothing new, one never knows when a new idea may be struck out from the discussion of old ones, as a spark from the rubbing together of cold flints.

I may say at the outset that I am no advocate of an exclusively scientific training. Boys of thirteen and fourteen—and their parents—are often obliged to choose between what are called the scientific and classical sides in a school. This I believe to be a distinct evil, though it is sometimes a necessary evil. The general or all-round education of the boy should be continued as long as possible, and it should still be open to him on entering the University to choose either a literary or a scientific career. These conclusions I consider to be based upon the mental constitution of all ordinary boys; I do not here speak of the genius. How can a schoolboy have a sufficient knowledge of himself or the world to recognize his true relation to his environment, and few parents indeed can so discern the fruit in the bud as to be able to decide what specialized course of training would be best suited to their sons. In every boy's life there comes a time—sometimes late and sometimes early—when he naturally reaches out into the future and considers, with more or less seriousness, according to his temperament, his relation to the world. Then, and not till then, can much value be attached to his instinctive

leaning to one path or another. The choice once made should be persevered in; there should be no turning back when the hand has been put to the plough.

Nor need it be imagined that young men are losing time when not directly preparing for some special sphere, for, in the opinion of many educators, the best training for a special sphere is that which will give the mind the largest grasp of which it is capable. What part science should play in this, is the question I would, with your permission, more particularly discuss.

Nor need it be imagined that young men are losing time when not them, it may be interesting to notice some recent definitions of the term "science." In the first place, science should be distinguished from knowledge. Quoting from the words of a well-known writer, "Knowledge of literature, of the beautiful things which have been written or otherwise produced by human ingenuity, is not science. Knowledge of the various manufacturing processes in use by civilised men is not science; nor knowledge of the names of the stars, or of the joints of a beetle's leg. Science cannot be identified with knowledge of any particular class of objects, however detailed that knowledge may be. It is a common mistake to consider all knowledge of raw products, of living objects, or other natural objects, as necessarily 'science.' The truth is, that a man may have great knowledge of these things as so many facts, and yet be devoid of 'science.' The mere knowledge, then, of any fact is not science. Science, again, is not to be confounded with invention—or its applications. It is of the utmost importance for the progress and well-being of science that this should be understood; that the eager, practical spirit of the inventor who gains large pecuniary rewards by the sale of his inventions should not be confounded with what is totally different and remote from it, namely, the devoted, searching spirit of science, which, heedless of pecuniary rewards, ever faces nature with a single purpose—to ascertain the causes of things."

Science, then, seems to be applied properly to our knowledge of the facts in the world in their relation to one another; above all, in their relation to cause and effect. An isolated fact even about nature may be called knowledge, but cannot be rightly called science until we have fitted it to some other fact,—until we have done something towards recognizing its place in the great order of the Universe.

> "That orbed maiden, with white fire laden,
> Whom mortals call the moon—"

is poetry, but when we ask the source of the "white fire," and trace it to the luminous corona of the sun, or when we ask how it reaches our senses, and how it excites the nerve of sight, we have left poetry, we have entered the territory of Science.

Now, what does this science do for us that should give it the right to enter as it is doing the domain of education. We may say, perhaps, putting the answer in its most general form, science makes us understand our material environment, which, if not our highest environment, is the absolutely essential medium through which our highest is known. It sets open for us doors on all sides. We can peer into the rifts of the rocks, and see, with Ruskin, how the quartz has been interlacing them with crystal threads; we can follow the flight of the winged seeds of the plants, can tell how these spread their rootlets in darkness and yet reach ever up to the light; we can trace out the family-trees of the birds and beasts; can turn our microscope on a drop of water and see into a world full of its own forms of life; can trace out our path among the stars, or our ceaseless journey into and out of the sunlight.

> "World of my life,
> Swing thee round thy sunny track.
> Fire and wind and water and strife,
> Carry them all to the glory back."

Through most of these doors we can take but a glance, but it is one of those potential glances which do not leave us where we were before.

> "Conceive, then, earth's resources! Vast
> Exhaustless beauty endless change of wonder!"

Our nature follows a law, like that of the diffusion of gases. Open the door, and forth it will pass to take possession of the new realm of knowledge.

If science gives us a knowledge of the world we live in, the *scientific method* goes far to settle the other half of the problem of our physical life, and by training our faculties, mental and moral, to fit us for that world.

It is no small compliment to science that in almost every study we hear of the application to that study of the scientific method. Great thinkers have written of the science of history, of the science of grammar, of the science of language. What does this mean? What is this process, which is considered so desirable?

The scientific method proceeds by way of observation, analysis, classification, generalization, deduction and experiment, names in some cases common to the processes and to the faculties by which they are carried out, as when we speak of a man's observations, and say, in the same breath, that he is a man of keen observation. This rather confusing language hints at the fact of the living relationship which exists between the two, so that no observation can be made without presupposing a faculty for it, and no faculty can be cultivated in any other manner than by using it. The importance of the

faculties referred to can hardly be over-estimated, and is being steadily more and more recognized on all sides. In the present war we have a most striking example of this. Has not each writer, in his own way, tried to impress us with the absolute necessity of using every sense and every faculty in war? What is Gen. Baden Powell's "Aids to Scouting" but a plea that special attention should be given, either by oneself or others, to the cultivation of those powers which necessity has often called out in the uneducated?

Of the keenness of observation shown by Indians we have hundreds of stories. I may instance two which have been told to myself. The late Dr. Beers, who gave so much thought to the welfare of the Indians, told me of one who came into his office and there saw an engraving which struck his fancy. He looked at it for a few minutes, then went away, and a few weeks afterwards sent back a painted reproduction, which bore a very remarkable resemblance to the original.

Again, a friend of mine, having occasion to pass two or three times along a road of perhaps several miles in length, through a forest, made a cache on the way, to prevent the necessity of carrying so much baggage. On the return journey the Indian guide stopped on the monotonous road, took a few steps to one side and drew out the hidden store, although a snow-storm in the meanwhile had completely obliterated every mark by which the place might have been known, to the ordinary observer. Could our Senior Classics or our Senior Wranglers rival this performance? I fear not yet, but this power of observation is the first lesson scientific education is trying to teach, and with no small amount of success.

The way in which our vaunted knowledge, combined with what appears to him ridiculous ignorance of our surroundings, strikes the savage, is amusingly illustrated in the opinions held by certain Indians of the North-West. Reasoning from the helplessness of the amateur hunter and ordinary traveller in distinguishing the natural signs and sounds in the woods, they designate the white man as "the foolish man." Being asked by the missionaries why they do not go to Church, they answer, "we have been there and have heard what you have to tell us, therefore we know it, and do not need to come and hear it a second time. The white man has to be told the same thing so often that he must always have his book tied to him."

Count Rumford points out how much the cause of science in general is likely to profit by the continual use of the seeing power which is the first process of the scientific method. He says:—"I am persuaded that a habit of keeping the eyes open to everything that is going on in the ordinary course of the business of life has oftener led, as it were by accident, or by the playful excursions of the imagination put into action by contemplating the most common appearances, to useful doubts, and sensible schemes

for investigation and improvement, than all the more intense meditations of philosophers, in the hours expressly set apart for study."

He himself hit on the true explanation of what becomes of work spent in friction, when superintending the boring of cannon in the Arsenal workshops at Munich.

No doubt to achieve such a result as this, observations must be of a special character. They should be minute, like those of Hunter, in his study of the deer's horns; they should be accurate, like those which led Adams and Leverrier to the simultaneous discovery of Neptune, and, above all, they should be selective, i.e., if we are following up a special point, we should be trained to fasten, as it were, on the fact which throws light on the question at issue, remembering that it is not always, or even usually, the prominent feature which will put us on the track of a discovery of true connections, but more often some small point, which the ordinary person passes by unheeding.

On one occasion, the Doctor, from whom Sherlock Holmes' picture was drawn, commiserated a complete stranger on having taken such a long walk that morning, and, seeing his look of surprise, explained in a matter-of-fact tone that there was no place within five miles where he could have got that splash of red mud upon his boot. The simplicity of the explanation when we know it does not make it the less remarkable.

And so with the other processes of the scientific method. Take analysis—which has sometimes to accompany observation. Its importance is seen when we reflect that objects in nature do not appear to us, as a rule, classified and docketed as they do in text books; in fact, the study of nature is oftener like reading a text book backwards. "You study nature in the house, and when you go out of doors you cannot find her."

Without classification, again, we cannot be truly scientific, keeping to the definition that we have chosen for science, for it is by this process that we fit observed facts into their proper place as it were, gathering up the new with the old into a larger synthesis.

Further, the necessity of carrying out of experiments has produced in many men a remarkable development of resourcefulness.

Wollaston, who was the first to demonstrate the identity of Galvanism and Electricity, when asked by a distinguished foreigner to show him his laboratory, immediately brought out a small tray containing a few glass tubes and a blowpipe. Elaborate apparatus were needless to him, as to most geniuses.

Naismith, too, was a fine example of resourcefulness, though, perhaps, he did not get his faculty from his scientific training, but came by it naturally, as it is related of his father, that, once being anxious to go to the Ranelagh, at which striped stockings were considered an essential, he himself washed his only pair and set them

in front of the fire to dry. The story goes on to say, that finding, when the time had arrived, that his stockings were reduced to a cinder, he repaired the damage, nothing daunted, and that his stockings were the envy of the room,—he had painted his legs.

What incessant call there is in all this for eager attention, concentration of mind, clearness of judgment, etc.! Indeed, in working out this scientific method, which I have tried to put before you,—this process of observation, analysis, comparison, judgment, synthesis, deduction, experiment—we shall find that nearly all the mental faculties, and not a few moral qualities, are brought into play.

If it be asked, what moral qualities are certainly cultivated by scientific work, the first that would be mentioned by most people is the love of truth. Now, while it is, of course, a fact that there may be a power of seeing truth without any corresponding love for it—which is the real moral quality—still, it must also be admitted that there are many people who think they have a love of truth, while in reality for want of the power of discernment, which science helps to teach, they may live a long life of self-deception, and swell the ranks of what we may call the "conscientious swindlers," who have been the bane of the Church and of Society. I may cite, as a practical illustration of the effect of scientific teaching, the testimony given to myself, by a teacher of an Industrial Class in New York, whose pupils were taken from the untrained class—that the boys try to deceive at first, but soon give it up when they find that their statements have to square with their finished work, which speaks for itself.

Neither does the benefit end here. The vision of truth, gradually unfolded before the inquiring spirit, tends to produce humility and reverence, especially in great minds; as witness the often quoted words of Sir Isaac Newton about the grand ocean of truth lying undiscovered, while he was like a boy playing on the shore. "Whatever service I have done the public," he says, "is not owing to any extraordinary sagacity, but solely to industry and patient thought." And these are the words of one, whose epitaph meets with universal consent for its conclusion, "let mortals rejoice that there has existed such and so great an ornament of the human race."

Nor has the humility led to want of effort, but the very contrary. In such a man as Morse, for instance, when struggling against the apathy of an indifferent public; "it will be too late," said he to a friend who was comforting him with the hope of help to come soon —"I shall be dead then." He had had no food for twenty-four hours, but fortunately it was the darkness before the dawn. As in his troubles he had shown no bitterness, so in his successes he showed no pride, but an ever-deepening reverence, which found fit expression in the first telegram sent over this continent,—"What hath God wrought."

Some, or all, of these qualities, may, it is true, be natural and

not trained. These men were geniuses, perhaps, but when we look round at the ranks of the men of science, and see how many of them have shown courage and endurance, accuracy and conscientiousness, reverence and love of truth, can we doubt that our complex nature is moulded by the very resistance with which it meets into a smoother outline, and pressed by the weight of difficulties into finer structure.

But while we claim all these advantages, and many more, for a truly scientific education, may not those who still look upon science as a poacher in the preserves of the ancient Classics, an unwelcome intruder into the regions of literature and of philosophy, may they not, I say, claim with equal justice, that, as this scientific method may be applied to all these studies, it must bring in its train most of the advantages I have enumerated as being the handmaidens of that stately damsel—Science? Perhaps, they may even add, that the scientific method, joined to the great intrinsic value of history and philosophy as educators, will gain instead of losing by its transfer to other soil

Well, grant that in History we learn the relation of cause and effect by the bitter experience of a French Revolution,—a reaction from grinding tyranny—grant that we can gain a sense of proportion from a comparison of the results of the different forces which have moved nations, also that our power of judging is brought into continual exercise by the problems of policy, and by the moral issues which face us as we in imagination follow the lives and struggles of the makers of history. Let us allow that the relation in which we stand to our forefathers and their times is just as real and as important as is our relation to the past forests of the carboniferous age, without which we would find it necessary to emigrate to a more torrid zone. And certainly we must admit that, if we want to train our memories by the accumulation of facts, we will find ample scope in history, and, I may add, in geography.

Language, ancient and modern, will also supply us with much material for improving our memories. As it is sometimes taught, indeed, it amounts to little else, each new language supplying only another word to express the same idea. The scientific method being applied, however, we at once begin to observe that the word in the new language is not an exact equivalent, that it covers, as it were, a little more or a little less ground, and then enters in the necessity for the selection of an equivalent.

This necessity for a nice discrimination in the choice of words, either in our own language or another, is one of the greatest possible helps to that clearness of thought which is so invariable a sign of a truly educated mind as to be almost a synonym for education. For the true use of words, if carried as far as it would take us, would guide us through every region of human knowledge, and

without right words, we must be lost in the unexplored lumber-rooms of our own brains.

Comparative Philology will undoubtedly bring in many educative influences, which will reveal much of the life of other nations, and words themselves, in their histories, are often epitomes of the course of thought—records of increasing clearness of vision.

As Oliver Wendell Holmes says:—"Language is a solemn thing. It grows out of life, out of its agonies and ecstacies, its wants and its weariness. Every language is a temple, in which the soul of those who speak it is enshrined.

Classification and the reasoning powers will be needed in the proper study of the structure of the various languages. English, at least, offers a fine scope in this direction. A language in which, according to a modern grammar, an adverb is perhaps usually an adverb, but on occasion shown, can turn itself conveniently into an adjective or a preposition, should certainly turn out a nation of clear reasoners.

The manifest educational advantages of literature are so often confounded with those of language even by educators that it is no wonder if youth confuses them, and that the literature comes in for its share in the dislike of the drudgery of language learning; no wonder that boys, who are popularly supposed to be learners in the school of taste, and embryo devotees at the shrines of noble thoughts, are really only learning to hate Horace and Aeschylus for not having had the foresight to say what they had to say in plain English.

We cannot but see, however, that literature allows of the use of the scientific method in the department which is called criticism. That here there is room for observation, analysis, discrimination, comparison, judgment, and that, over and above this, that it extends our horizon, enabling us to read the thought and feel the emotions of men of other ages and other lands.

Philosophy, in one sense, has exactly the same aim as science, namely, the search for truth, but it does not cover exactly the same ground; both search for truth, but not for the whole of truth.

Science tries to find out the workings of the material universe, and philosophy, in the limited sense in which we usually employ it, i.e., mental and moral philosophy,—in this limited sense, I say, it tries to find out the workings of the human mind.

In a great degree, also, both have the same method, so that actually the same words will describe the processes in both science and philosophy.

Thus, Sir W. Hamilton says, "In Bacon and Descartes our modern philosophy may be said to originate, inasmuch as they were the first who made the doctrine of method a principal object of consideration. They both proclaimed, that, for the attainment of scien-

tific knowledge, it is necessary to observe with care,—that is to analyse; to reject every element as hypothetical, which this analysis does not spontaneously afford; to call in experiment in aid of observation, and to attempt no synthesis or generalization, until the relative analysis has been completely accomplished. They showed that previous philosophers had erred, not by rejecting either analysis or synthesis, but by hurrying on to synthetic induction from a limited or specious analytic observation. They propounded no new method of philosophy; they only expounded the conditions of the old. They showed that these conditions had rarely been fulfilled by philosophers in time past; and exhorted them to their fulfilment in time to come. They thus explained the petty progress of the past philosophy, and justly anticipated a gigantic advancement for the future. Such was their precept, but such unfortunately was not their example. There are no philosophers who merit so much in one respect; none, perhaps, who deserve less in the other."

Philosophy can scarcely be said to train the observing powers, for the term "observation" is usually limited to the training of the senses, especially the eye, to notice and distinguish material facts, but in a sense—and a very real sense—it does proceed from the observation of facts, for we can observe the characters and emotions of men singly or in groups, and observe them to some purpose. We read of Marlborough:—"The passions which stirred the men around him, whether noble or ignoble, were to him simply elements in an intellectual problem which had to be solved by patience." . . . . "There was a touch of irony in the simple expedients by which he sometimes solved problems which had baffled Cabinets. The touchy pride of the King of Prussia made him one of the most vexatious among the allies, but all difficulty with him ceased when Marlborough rose at a State banquet and handed him—a napkin."

Napoleon's success, about which so much has been written, was also largely due to knowledge of men.

In philosophy, then, no less than in literature, we can discriminate and compare and judge; we can classify and finally generalize and try to arrive at an underlying principle from which again we can deduce theories, for instance, of government or of education. We can even test these theories by true experiments carried out in as scientific a manner as possible.

The conditions here are even more complex than in scientific experiments. It is much more difficult to determine what the facts are, very much more difficult to arrive at principles; so much so that one has said, "When from the phenomena of life we pass to those of mind, we enter a region still more profoundly mysterious. . . Science can be expected to do but little to aid us here, since the instrument of research is itself the object of investigation. It can but enlighten us as to the depth of our ignorance, and lead us to look to a higher aid for that which most nearly concerns our well-being."

The scientific method, then, can actually be applied to history, language, literature and philosophy—and we will even go further than this and admit cheerfully that there are certain things which science should never be expected to teach to the ordinary mind—and things of so much value that it would be one-sided indeed to exclude them from any well-balanced scheme of education.

It is true that observation and imagination play a great part in science, yet years of study of ornithology would not have taught anyone to see the relations between a lark and a poet, which made Shelley sing in addressing his skylark,

> "Like a poet hidden
> In the light of thought,
> Singing hymns unbidden,
> Till the world is wrought
> To sympathy with hopes and fears it heeded not."

It is true "that there is an infinite miracle in every tuft of grass," if we have only eyes to see it—it is true that science opens new vistas to the man who can feel the joy and peace of Nature, who can draw inspiration from the wildness of its rugged hills, from the varied beauties of its flowering dales, from the ever-changing hues of the woods, from the rivers meandering through sunlit plains, from the constantly changing colours which play as it were on the face of the ocean, or from the loveliness of the June sky,—when

> ". . . . heaven tries the earth if it be in tune,
> And over it softly her warm ear lays."

It is true also that the telescope and the microscope have opened up to the student of science new worlds of marvellous interest and beauty, whose threshold we seem scarcely to have crossed, giving hints to the wise of what may be in the infinite beyond "the arras-folds that variegate the earth, God's 'antechamber,'" but we can hardly say that science actually trains the power of seeing beauty of form or colour—of perceiving the emotional force, as it were, of nature. This must come from a natural faculty, and according to the best part of the teaching of the new German philosophy, "the gladness that men feel when they are in touch with the overflowing and intoxicating power of nature" is itself an important source of energy. As Coleridge puts it,

> "Oh Lady! we receive but what we give,
> And in our life alone does nature live."

If this power of vision is to be cultivated it must be by means
There is another direction in which it is desirable to get a clearer definition. The great good which arises from the power given by of some such studies as art, music or poetry.

Science of verifying every observation tends to make us exaggerate the service thus rendered, and to require that every kind of truth should be verified by the same kind of proof. To such an extent is this carried that it causes some minds to refuse to accept any of the mysteries of the universe without absolute demonstration—hence, from lack of exercise, their faculty of seeing with the inner eye is in danger of atrophy.

Yet the fact that Science will not teach faith is no proof that it is not a very real factor in the problem of life. And if it is—then it should be cultivated by other training—by opening our eyes to the relations of man to man, and of man to God, "if haply we may feel after Him and find Him," by acting on the principle which we wish to believe until we feel the ground under our feet, or as the French saying has it, "En avant! et la foi te viendra."

Now, admitting then, as I have done, that the scientific method with its attendant advantages can be, and already have been, in part, applied to many branches of learning, and admitting further that it will not teach everything, *I would yet claim for the application of the scientific method to the teaching of Science itself that by it certain results can be obtained which can be obtained in no other way.* For example:—

1. In the first place, that we find the scientific method applied in every branch of knowledge involves, I think, the tacit acknowledgment that it is the best known method of study. This being the case, it becomes of great importance that the method itself should be studied, and that—where it can best be learned—in man's laboratory and Nature's workshop, for, in practice, if this is not done, it is very difficult to ensure that the method will ever be learned at all, or that there will be any reasonable chance of its being applied to the other studies. In how many classes are literature, history and philosophy, and even science itself, merely crammed from books, and not studied in any proper sense at all?

2. Again, one of the most characteristic features of the scientific method *when applied to science* is that it necessitates the careful training of the eye, the ear and the hand—especially the hand—demanding a skill of manipulation, which tends to turn the man of thought into the man of action. We may rest assured that it does not mean nothing when we find the close association of great genius in works of the hand, with that wonderful practical capacity in other directions—in conquest, in laws and institutions, in government of men—which built up the Roman Empire. Experience has now shown that many minds are more easily approached and more readily developed by the systematic exercise of the sense of touch than in any other way. "Neither the naked hand nor the understanding left to itself can do much. The work is accomplished by instruments and helps, of which the need is not less for the under-

standing than for the hand." Perhaps no more striking proof of this fact can be given than the statistics of the various manual training schools, from which we learn that an increasing army of useful citizens has been—I would almost say—created out of that class from which so little had been hitherto expected.

3. Thirdly, an advantage necessarily arising from the carrying out of the experiments required in so many departments of scientific work is the development of a keen and accurate perception of the truth by the constant checking of results. Our thoughts at every stage are crystallized into facts, and we are prevented from wandering into the often too hazy regions of hypothesis, and what is frequently mis-called pure thought—into the kind of thing which the Scotchman said was "no deep, but drumlie."

4. Again, in experimental work, the cause and its results are brought into such close juxtaposition as to throw into the strongest possible relief the relation of cause and effect—the most fundamental in our seachings after truth.

5. The scientific method also involves, of course, that constant and steady accumulation of facts, erroneously looked upon by many as synonymous with science, but which is more truly regarded as the material of science. We can never tell what fact will prove the starting point of some fresh discovery.

6. Further, the learning of science fits a man directly to understand his environment, to cope with the every-day circumstances of his material surroundings, and therefore tends to develop in him common-sense and practicality.

7. It offers more scope for the free exercise of the powers, always very stimulating to interest in the student, and incidentally gives to the educator better opportunities for judging the particular bent of the character with which he has to deal.

"Because, says Plato, no trace of slavery ought to mix with the studies of the freeborn man. For the constrained performance of bodily labours does, it is true, exert no evil influence upon the body; but, in the case of the mind, no study, pursued under compulsion, remains rooted in the memory. Hence, you must train children to their studies in a playful manner and without any air of constraint, with the further object of discerning more readily the natural bent of their respective characters."

8. Finally, although it is hardly true, as is so often alleged, that the training in literature and language does not directly prepare a man for an immediately remunerative career—for what other preparation is considered necessary for the teacher, for the journalist, for the author, for the diplomat, or the politician?—still, it is more often the case that the teaching of science will prepare a man directly for his after-career, and for the prosaic but very necessary duty of as soon as possible earning his bread and butter.

Other points, such as the development of the faculty of resourcefulness, to which I have before referred, might no doubt be mentioned, but if we consider the very manifest advantages now given as essential to our well-being, *should it not be our duty to require that science should be taught to every one?*

Even after we have made up our minds how far Science will and how far it will not help us in that development of the natural powers which is so large a part of Education, we are still much hampered and hindered by circumstances which make it very difficult for us to carry out our ideals.

Speaking for many Universities, we have a class of students entering them too young and too untrained to make an intelligent choice of subjects, and we have a large mass of opinion, both in and out of the University, in favour of the theory that in a country where young men must earn their own living at an early age the training which they receive should all bear directly on their chosen profession with a view to the saving of time.

This is a very natural if somewhat superficial idea, and the conflict of opinion becomes sometimes quite bitter between those who maintain it, and those who believe that "the longest way round is sometimes the shortest way home," who believe the theory, formulated slowly through ages of comparative leisure, that the aim of teaching should be wholly, or in great part, educational, and that the purely practical should be added only at the very latest stage.

In the meantime, perhaps, one of the best compromises can be found in the further working out of the option system.

The student might be allowed to choose his own subjects with even greater freedom than at present. His choice would, in all probability, be governed largely by the necessities of practical life, that is, he would choose those studies which he thinks will most directly fit him for the career which seems open to him. In the teaching of these subjects, however, in any institution worthy the name of a university, the method to be pursued should be primarily, if not exclusively, educational.

To give a rough example of what I mean. Suppose a boy is to be trained for business. A thorough knowledge of bookkeeping will, no doubt, be essential, but we can imagine that, in the end, foresight, accuracy, grasp of the large and the small, a thorough knowledge of men, might be of still greater importance, and that it would be better to sacrifice even some actual knowledge of useful details, rather than to teach without cultivating the faculties which would be ultimately necessary to any considerable success.

Now, as it happens, the study of engineering, which I have called the study of a combination of certain sciences, joined together with a view to their practical application, offers an easy opportunity for just such a compromise as we have

found to be extremely desirable in itself. The subjects chosen for training may, nay, almost must, be those required in the after-practice of the profession, but at the University we need not aim at giving a thorough knowledge of all these, but rather at inculcating the power to deal with any set of circumstances and to use the knowledge, which books or experience have provided. As an actual fact, we have found that the success of our students often arises from this very power.

Besides the purely educational results, which I have tried to show, are obtained from the study of science, there are certain other advantages to which I may just refer, and which are so considerable as to give to science an almost unrivalled claim on our attention. Such are the constantly increasing benefits which science, and especially engineering science, has conferred on all classes of society, in the great improvements in material condition; the practical overthrow of the barriers of time and space, and last, but not least, the great intellectual quickening, due to easier contact of mind with mind, which has come in the train of printing and photography, of steam and electricity.

Some one has said, "Every advance in intellectual education has been the effect of some considerable scientific discovery or group of discoveries." This is a subject which, at the entrance of another century, we are almost afraid to do more than suggest. Everyone is giving his views, and looking forward, with a confidence born of pride in the achievements of the Nineteenth Century, to certain conquests in the Twentieth. Perhaps we would do well to remember that we are no longer fin-de-siècle, but only commencing a new century

> "Down the roads we do not know,
> With our orders sealed we go."

As men of the Twentieth Century, we should not boast as we put on our armour, but rather see that we also are equipped with the patience and determination of a Darwin, the resourcefulness of a Stephenson, the reverent humility of a Faraday, for then and then only, can we hope to win from Nature those secrets which will enable us to enter upon our inheritance, and to find out yet unthought of meanings of the first command to "subdue the earth."